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Chemical Weapons Nonproliferation: Confronting New Technological Challenges

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As a result of the injuries inflicted by chemical warfare during the First World War, the Geneva Protocol of 1925 was established to ban the use of asphyxiating and poisonous gases in international conflict. However, the possession of such agents was not restricted. The stockpiling of chemical weapons (CW) continued throughout World War II and the Cold War with the development of more lethal and sophisticated agents. The continuing threat of chemical warfare and the actual use of CW in the developing world, including large scale use in the Iran-Iraq war, led to multilateral negotiations in the 1980's to ban the use, production, stockpiling, and transfer of chemical weapons. To that end, the Chemical Weapons Convention[1] (CWC) was opened for signatures in January 1993 and subsequently entered force on April 29, 1997. The convention seeks to eliminate stockpiles of agents and weapons possessed by nation states. It was not focused on non-state threats, such as terrorism. The prevailing view among convention negotiators was that to effectively utilize chemical weapons for a military purpose, nation states needed large stockpiles of agents. The CWC was drafted according to the practices of the chemical industry at the time. Essentially, "the framers[15] of the CWC had a sense that they were dealing with a finite universe of potentially CW-capable facilities that the convention had to address." However, recent technological advancements within the chemical industry are challenging the finite nature of these potentially CW-capable facilities even as priority is given to preventing CW acquisition and use by terrorists. In this context, new approaches to standby or breakout technology have the potential to threaten the effectiveness of the CWC's provisions for verification and compliance.

The CWC defines chemical weapons comprehensively and contains an unprecedented and intrusive verification mechanism, going far beyond other treaties banning weapons of mass destruction (the 1968 nuclear Non-Proliferation Treaty and the 1972 Biological Weapons Convention). Essential to the continued efficacy of both the comprehensiveness and verifiability of the CWC is the provision in Article VIII for Review Conferences to "take into account any relevant scientific and technological development." The Scientific Advisory Board (SAB) for the CWC prepared a report[2] on relevant advancements in science and technology for the First Review Conference that took place from April 28 through May 9, 2003. Among others, two key issues arose: first, newly discovered toxic agents "that cause considerable harm" that are not listed on the schedules; and second, the development of new chemical production processes. The former has been debated extensively; the latter has not received much attention.

Article II of the CWC defines chemical weapons "as toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes." These included definitions and provisions are referred to as the General Purpose Criterion[3] (GPC), which provides the comprehensive prohibition of unscheduled chemicals as well as scheduled chemicals that might be used for weapons or for non-peaceful purposes. With new chemicals and processes being created continuously, the list of designated chemicals on the schedules cannot realistically be all-inclusive. Consensus exists that novel or currently unknown agents are covered under the convention, although how this will be translated into monitoring and verification remains less clear than for scheduled chemicals, especially when new development and production processes are involved. Advancements in science and technology to produce agents remain a concern that is not well understood or covered by the CWC protocols. Among the many technologies identified in an IUPAC (International Union of Pure and Applied Chemistry) technical report[4] is the development of microprocess capabilities. Research in microtechnology has grown rapidly within the last decade and has garnered much attention in both academia[5] and industry.[6] Miniaturized reaction systems for chemical synthesis and production present many advantages over traditional batch vessel methods. Microreactors possess inner channels that are generally under a millimeter in diameter, thus increasing the surface area to volume ratio as compared to conventional chemical reactors. Heat transport, mass transport, and hydrodynamic flow in the microchannels are aspects[7] that are important to their function. Highly exothermic reactions, such as the fluorination[8] of toluene, can be performed at higher temperatures and with better selectivity than in conventional batch equipment. The physical hazards associated with chemical synthesis are greatly reduced.

As noted in a report[9] on microreactors in ACHEMA 2003, "continued development of these devices is expected to drive construction of miniature chemical plants that are inherently safe, and can operate in an explosive or hazardous regime that may be off-limits to a conventional plant and equipment." Diverse reactions, such as the Wittig, Michael-addition, Diels-Alder, condensations, halogenations, oxidations, reductions and others, have been performed successfully[10] with microreactors, and in most cases, with improved results. Although the full CW chemical synthesis potential of microreactors is not yet clear, the syntheses of lethal chemicals such as hydrogen cyanide, phosgene and methyl isocyanate, the toxic agent involved in the Bhopal incident in 1984, have been demonstrated. In a more complex example, the multistep synthesis[13] of ciprofloxacin, an antibiotic used to treat anthrax infection, has been accomplished using microreactors.

Along with the industrial advantages presented by microprocess technology comes the potential to producechemicals for chemical weapons. The inherently small physical size of the equipment for microprocess technology and small space required, make it attractive for clandestine operations. The ability to produce chemicals of interest in a safer and more feasible manner, with little signature produced, could encourage their application for malicious intent. Chemical weapon precursors could be synthesized instead of purchased. "Just in time" production of chemicals could be facilitated by the use of Microreactors, which would also reduce the risk of discovery and of handling and storage of dangerous and toxic chemicals in large quantities, a problem associated with weaponization. One distinct advantage of microprocess chemical synthesis is the avoidance of scale-up research and development. Instead of large reactors, multiple microreactors performing the same chemical reaction would serve the same purpose.

This method has been referred to as numbering up. Although one microreactor could produce a significant amount of chemicals depending on the flow rate over time, a cluster of microreactors performing the same chemical reaction with the same reaction parameters in high throughput would allow for large-scale production of chemicals, avoiding scale-up and storage drawbacks of conventional batch processes.

The benefits of microprocess technology are apparent. It has the potential to change and alter the current chemical production industry. Microprocess technology is in its infancy in terms of development and widespread application and as a result, proliferation risks can be overlooked. This technology is an example of an advancement that could potentially alter the expected list of signatures for chemical weapons, thus creating more challenges for nonproliferation efforts. However, because the technology is not yet widely used, now is the time to review the technology while it is more manageable. The difficulties and challenges posed to security by dual use technologies and capabilities, such as this, are evident. Effective measures for control and verification must not curtail the development and growth of such technologies. Yet the security challenges should not be ignored.

Iraq's use of chemical agents in it's war with Iran, the subway release of sarin by Aum Shinrikyo in Japan, and Libya's recent declaration of chemical agents possession are clear indicators that proliferation, by both States and non-States, remains a concern and that dealing with "just-in-time" production capability needs to be addressed. Pilot plants[9] using microreactors to perform continuous flow organic synthesis have been established. With these scientific and technological advancements, traditional large-scale production facilities could make way for diverse and more efficient microplants with multipurpose capabilities. An increasingly evidant dual-use potential for these technologies in the chemical industry would render verification of the intent for peaceful purposes difficult. Declaration and inspection provisions present in the CWC seek to determine the presence and stockpiling of chemical weapons or the capability for their development and production. A core component of compliance verification of the CWC is the accurate identification and effective inspection of chemical production facilities through both routine and challenge inspections.

Thus, with the introduction of micro process technology, the Organization for the Prohibition of Chemical Weapons (OPCW) is faced with new challenges in identifying and monitoring chemical facilities to ensure the effectiveness and viability of the CWC. With numerous publications detailing advancements already achieved with this production technology, potential security and chemical weapons proliferation implications are evident. To address these issues, the OPCW needs to begin by partnering, not only with industry experts, but also with innovators of this technology to determine and identify the precise and immediate threats associated with these advancements. What is the potential for widespread proliferation? As stated in a recent[14] article, "microreactors are cheap and easy to replace, and promise to accelerate process development." How will security interests not hinder[16] the technology's development and economical impact? What are the CWC definitional uncertainties, and how would it affect the current declaration thresholds? Is export control necessary? The Australia Group[17] is an informal arrangement of thirty-three participating states and the European Commission that aims to minimize the risk of assisting chemical and biological weapon proliferation by ensuring cooperative national export licensing. The question of obligation from non-member States often confronts multilateral regimes. Transparency and outreach efforts are critical to tackling this challenge. Efforts should be made to increase understanding of nonproliferation goals in order to promote adherence to the set guidelines for export control. Transit states in parts of Asia, where sensitive technologies exist, have only limited, unilateral export controls, without any international restraints or responsibilities. These responsibilities should also foster stronger national implementation[18] measures required by Article VII of the CWC. Comprehensive national legislation empowers member States and the OPCW thereby providing more effective means for enforcement of compliance. With the unanimous adoption[19] of United Nations Security Council Resolution 1540 in April 2004, a crucial step towards addressing the threat that WMD proliferation, as well as their means of delivery, pose on international peace and security has been taken. UNSCR 1540 specifically tackles the problem of proliferation by Non-State actors by calling on State Parties to adopt national legislations that criminalize proliferation activities and by developing appropriate, effective export controls. Thus, UNSCR 1540 compliments and further enables the objectives of the CWC.

These questions and others will undoubtedly have to be addressed through discussions. Assessments of current and near future capabilities related to microprocess technology and an awareness of the trade in this technology are necessary to provide an understanding of the threats. Once these threats are identified, the OPCW and governments can then take appropriate measures to ensure effective global implementation of the CWC without compromising the peaceful contributions of this promising technology.

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